

What is claimed is:

1 1. A method for concealing the effects of frame errors in frames
2 to be decoded by a decoder in providing synthesized speech, the
3 frames being provided over a communication channel to the
4 decoder, each frame providing parameters used by the decoder in
5 synthesizing speech, the method comprising the steps of:

6 a) determining whether a frame is a bad frame; and
7 b) providing a substitution for the parameters of the bad frame
8 based on an at least partly adaptive mean of the spectral
9 parameters of a predetermined number of the most recently
10 received good frames.

1 2. A method as in claim 1, further comprising the step of
2 determining whether the bad frame conveys stationary or non-
3 stationary speech, and wherein the step of providing a
4 substitution for the bad frame is performed in a way that depends
5 on whether the bad frame conveys stationary or non-stationary
6 speech.

1 3. A method as in claim 2, wherein in case of a bad frame
2 conveying stationary speech, the step of providing a substitution
3 for the bad frame is performed using a mean of parameters of a
4 predetermined number of the most recently received good frames.

1 4. A method as in claim 3, wherein in case of a bad frame
2 conveying stationary speech and in case a linear prediction (LP)
3 filter is being used, the step of providing a substitution for
4 the bad frame is performed according to the algorithm:

5 For $i = 0$ to $N-1$:

6 *adaptive_mean_LSF_vector(i)*
7 $= (\text{past_LSF_good}(i)(0) + \text{past_LSF_good}(i)(1) + \dots + \text{past_LSF_good}(i)(K-1)) / K;$
8 *LSF_q1(i)*
9 $= \alpha * \text{past_LSF_good}(i)(0) + (1 - \alpha) * \text{adaptive_mean_LSF}(i);$
10 *LSF_q2(i) = LSF_q1(i);*

11 wherein α is a predetermined parameter, wherein N is the order
12 of the LP filter, wherein K is the adaptation length, wherein
13 *LSF_q1(i)* is the quantized LSF vector of the second subframe and
14 *LSF_q2(i)* is the quantized LSF vector of the fourth subframe,
15 wherein *past_LSF_good(i)(0)* is equal to the value of the
16 quantity *LSF_q2(i-1)* from the previous good frame, wherein
17 *past_LSF_good(i)(n)* is a component of the vector of LSF
18 parameters from the $n+1^{\text{th}}$ previous good frame, and wherein
19 *adaptive_mean_LSF(i)* is the mean of the previous good LSF
20 vectors.

1 5. A method as in claim 2, wherein in case of a bad frame
2 conveying non-stationary speech, the step of providing a
3 substitution for the bad frame is performed using at most a
4 predetermined portion of a mean of parameters of a predetermined
5 number of the most recently received good frames.

1 6. A method as in claim 2, wherein in case of a bad frame
2 conveying non-stationary speech and in case a linear prediction
3 (LP) filter is being used, the step of providing a substitution
4 for the bad frame is performed according to the algorithm:

5 For $i = 0$ to $N-1$:
6 *partly_adaptive_mean_LSF(i)*
7 $= \beta * \text{mean_LSF}(i) + (1 - \beta) * \text{adaptive_mean_LSF}(i);$
8 *LSF_q1(i)*
9 $= \alpha * \text{past_LSF_good}(i)(0) + (1 - \alpha) * \text{partly_adaptive_mean_LSF}(i);$

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10      LSF_q2(i) = LSF_q1(i);
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11 wherein N is the order of the LP filter, wherein α and β are
12 predetermined parameters, wherein $LSF_q1(i)$ is the quantized LSF
13 vector of the second subframe and $LSF_q2(i)$ is the quantized LSF
14 vector of the fourth subframe, wherein $past_LSF_q(i)$ is the
15 value of $LSF_q2(i)$ from the previous good frame, wherein
16 $partly_adaptive_mean_LSF(i)$ is a combination of the adaptive
17 mean LSF vector and the average LSF vector, wherein
18 $adaptive_mean_LSF(i)$ is the mean of the last K good LSF vectors,
19 and wherein $mean_LSF(i)$ is a constant average LSF.

1 7. A method as in claim 1, further comprising the step of
2 determining whether the bad frame meets a predetermined
3 criterion, and if so, using the bad frame instead of substituting
4 for the bad frame.

1W 8. A method as in claim 7, wherein the predetermined criterion
2 involves making one or more of four comparisons: an inter-frame
3 comparison, an intra-frame comparison, a two-point comparison,
4 and a single-point comparison.

9. A method for concealing the effects of frame errors in frames to be decoded by a decoder in providing synthesized speech, the frames being provided over a communication channel to the decoder, each frame providing parameters used by the decoder in synthesizing speech the method comprising the steps of:

6 a) determining whether a frame is a bad frame; and
7 b) providing a substitution for the parameters of the bad
8 frame, a substitution in which past immittance spectral
9 frequencies (ISFs) are shifted towards a partly adaptive mean
10 given by:

11 $ISF_q(i) = \alpha * past_ISF_q(i) + (1 - \alpha) * ISF_{mean}(i)$, for $i = 0..16$,

12 where

13 $\alpha = 0.9$,

14 $ISF_q(i)$ is the i^{th} component of the ISF vector for
15 a current frame,

16 $past_ISF_q(i)$ is the i^{th} component of the ISF vector
17 from the previous frame,

18 $ISF_{mean}(i)$ is the i^{th} component of the vector that
19 is a combination of the adaptive mean and the constant
20 predetermined mean ISF vectors, and is calculated using the
21 formula:

22 $ISF_{mean}(i) = \beta * ISF_{const_mean}(i) + (1 - \beta) * ISF_{adaptive_mean}(i)$, for $i = 0..16$,

23 where $\beta = 0.75$, where $ISF_{adaptive_mean}(i) = \frac{1}{3} \sum_{i=0}^2 past_ISF_q(i)$ and is
24 updated whenever $BFI = 0$ where BFI is a bad frame indicator,
25 and where $ISF_{const_mean}(i)$ is the i^{th} component of a vector
26 formed from a long-time average of ISF vectors.

1 10. An apparatus for concealing the effects of frame errors in
2 frames to be decoded by a decoder in providing synthesized
3 speech, the frames being provided over a communication channel to
4 the decoder, each frame providing parameters used by the decoder
5 in synthesizing speech, the apparatus comprising:

- 6 a) means for determining whether a frame is a bad frame; and
7 b) means for providing a substitution for the parameters of the
8 bad frame based on an at least partly adaptive mean of the
9 spectral parameters of a predetermined number of the most
10 recently received good frames.

1 11. An apparatus as in claim 10, further comprising means for
2 determining whether the bad frame conveys stationary or non-
3 stationary speech, and wherein the means for providing a
4 substitution for the bad frame performs the substitution in a way
5 that depends on whether the bad frame conveys stationary or non-
6 stationary speech.

1 12. An apparatus as in claim 11, wherein in case of a bad frame
2 conveying stationary speech, the means for providing a
3 substitution for the bad frame does so using a mean of parameters
4 of a predetermined number of the most recently received good
5 frames.

1 13. An apparatus as in claim 12, wherein in case of a bad frame
2 conveying stationary speech and in case a linear prediction (LP)
3 filter is being used, the means for providing a substitution for
4 the bad frame is operative according to the algorithm:

5 For $i = 0$ to $N-1$:

6 adaptive_mean_LSF_vector(i)

7 $= (\text{past_LSF_good}(i)(0) + \text{past_LSF_good}(i)(1) + \dots + \text{past_LSF_good}(i)(K-1)) / K;$

8 LSF_q1(i)

9 $= \alpha * \text{past_LSF_good}(i)(0) + (1-\alpha) * \text{adaptive_mean_LSF}(i);$

10 LSF_q2(i) = LSF_q1(i);

11 wherein α is a predetermined parameter, wherein N is the order
12 of the LP filter, wherein K is the adaptation length, wherein
13 LSF_q1(i) is the quantized LSF vector of the second subframe and
14 LSF_q2(i) is the quantized LSF vector of the fourth subframe,
15 wherein $\text{past_LSF_good}(i)(0)$ is equal to the value of the
16 quantity LSF_q2($i-1$) from the previous good frame, wherein
17 $\text{past_LSF_good}(i)(n)$ is a component of the vector of LSF

18 parameters from the $n+1^{\text{th}}$ previous good frame, and wherein
19 $\text{adaptive_mean_LSF}(i)$ is the mean of the previous good LSF
20 vectors.

1 14. An apparatus as in claim 11, wherein in case of a bad frame
2 conveying non-stationary speech, the means for providing a
3 substitution for the bad frame does so using at most a
4 predetermined portion of a mean of parameters of a predetermined
5 number of the most recently received good frames.

1 15. An apparatus as in claim 11, wherein in case of a bad frame
2 conveying non-stationary speech and in case a linear prediction
3 (LP) filter is being used, the means for providing a substitution
4 for the bad frame is operative according to the algorithm:

5 For $i = 0$ to $N-1$:

6 $\text{partly_adaptive_mean_LSF}(i)$

7 $= \beta * \text{mean_LSF}(i) + (1-\beta) * \text{adaptive_mean_LSF}(i);$

8 $\text{LSF_q1}(i)$

9 $= \alpha * \text{past_LSF_good}(i)(0) + (1-\alpha) * \text{partly_adaptive_mean_LSF}(i);$

10 $\text{LSF_q2}(i) = \text{LSF_q1}(i);$

11 wherein N is the order of the LP filter, wherein α and β are
12 predetermined parameters, wherein $\text{LSF_q1}(i)$ is the quantized LSF
13 vector of the second subframe and $\text{LSF_q2}(i)$ is the quantized LSF
14 vector of the fourth subframe, wherein $\text{past_LSF_q}(i)$ is the
15 value of $\text{LSF_q2}(i)$ from the previous good frame, wherein
16 $\text{partly_adaptive_mean_LSF}(i)$ is a combination of the adaptive
17 mean LSF vector and the average LSF vector, wherein
18 $\text{adaptive_mean_LSF}(i)$ is the mean of the last K good LSF vectors,
19 and wherein $\text{mean_LSF}(i)$ is a constant average LSF.

1 16. An apparatus as in claim 10, further comprising means for

2 determining whether the bad frame meets a predetermined
3 criterion, and if so, using the bad frame instead of substituting
4 for the bad frame.

1 17. An apparatus as in claim 16, wherein the predetermined
2 criterion involves making one or more of four comparisons: an
3 inter-frame comparison, an intra-frame comparison, a two-point
4 comparison, and a single-point comparison.

1 18. An apparatus for concealing the effects of frame errors in
2 frames to be decoded by a decoder in providing synthesized
3 speech, the frames being provided over a communication channel to
4 the decoder, each frame providing parameters used by the decoder
5 in synthesizing speech the apparatus comprising:

- 6 a) means for determining whether a frame is a bad frame; and
7 b) means for providing a substitution for the parameters of the
8 bad frame, a substitution in which past immittance spectral
9 frequencies (ISFs) are shifted towards a partly adaptive mean
10 given by:

11
$$ISF_q(i) = \alpha * past_ISF_q(i) + (1 - \alpha) * ISF_{mean}(i), \text{ for } i = 0..16,$$

12 where

13
$$\alpha = 0.9,$$

14 $ISF_q(i)$ is the i^{th} component of the ISF vector for
15 a current frame,

16 $past_ISF_q(i)$ is the i^{th} component of the ISF vector
17 from the previous frame,

18 $ISF_{mean}(i)$ is the i^{th} component of the vector that
19 is a combination of the adaptive mean and the constant

20 predetermined mean ISF vectors, and is calculated using the
21 formula:

22
$$ISF_{mean}(i) = \beta * ISF_{const_mean}(i) + (1 - \beta) * ISF_{adaptive_mean}(i), \text{ for } i = 0..16,$$

23 where $\beta = 0.75$, where $ISF_{adaptive_mean}(i) = \frac{1}{3} \sum_{j=0}^2 past_ISF_q(i)$ and is
24 updated whenever BFI = 0 where BFI is a bad frame indicator,
25 and where $ISF_{const_mean}(i)$ is the i^{th} component of a vector
26 formed from a long-time average of ISF vectors.

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